Consortium Dealing With Reliability And Packaging Roadblocks To The Commercialization Of Microsystems

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Biography:
Frank Hartley has a background in the development of real-time-computing measurement control and analysis systems. At JPL he has been actively involved in the development of a variety of micromachined devices and 'smart' sensors and effectors. He has been at JPL for eight years as Supervisor of the Advanced Test and Measurement Group and more recently as Senior Technical Staff working on special projects. Prior to joining JPL he had been a business partner in numerous control system engineering tasks, in areas of transport, aviation, communications, medical, agricultural, defense, industrial and power utilities, as manager and engineer. He is a prolific innovator of technology and holds both foreign and USA patents. He received B.S. degrees in both Applied Physics and Electrical Engineering from the Royal Melbourne Institute of Technology and a M.S. degree from Cambridge University UK.

Abstract:

JPL has successfully applied coherent design and qualification methodologies to build ultra-reliable robotic spacecraft by exploiting knowledge of the failure and degradation mechanisms of macro-sized, essentially obsolescent, structures and systems. But, the days of macro spacecraft are over. Future spacecraft/sciencecraft will be made up of ultra-reliable microstructures and MEMS sensors and actuators.

The building of ultra-reliable "micro" spacecraft requires the identification of failure and degradation mechanisms – the same inhibitors to the commercialization of "micro" devices. JPL identified this synergy with industry and established a consortium to focus on resolving these technological issues.

Manufacture of reliable microstructures and MEMS devices requires stable, mature and large-scale production programs. None of these criteria are met in the ultra-low volume fabrication typical of NASA and other research establishments. JPL is researching these product assurance issues with devices supplied by industrial consortium members.

The mechanical and other physical properties of materials at the microscopic scale differ from the properties of (bulk) material at the mesoscopic or macroscopic scales. The surface finish, crystalline structure, grain size, micro-bonds and morphological irregularities playing significantly greater roles in determining a materials "properties". The physical properties of a material are also influenced greatly by fabrication techniques (such as crystal, epitaxial and sputter growth), multiple materials, dopants plus fabrication and annealing temperatures.

The cost of MEMS development and ultimately the reliability of MEMS are adversely affected by the many design iterations required to characterize the physical properties of materials and to 'tune' the physical structure of devices with respect to these properties. The consortium has identified the need for, and is consolidating sponsorship to produce, handbooks on "MEMS Quality and Reliability" and "Strengths of Materials."

Testing of MEMS devices is a major cost for the industry and testing protocols and techniques are crucial in accelerated life test validation. JPL is applying its environmental testing expertise to the development of new stress testing procedures and systems. Traditional product assurance and failure identification mechanisms of AFM, micro X-ray, ultrasonic & SEM are being applied to fracture, wire bond, structural faults, debris, and delamination analysis.

An outline of the consortium's programs and sponsorship consolidations will be presented in the form of a predictive roadmap. Finally a strategy for extending the scientific and engineering expertise of JPL and consortium members to small MEMS companies and research establishments will be addressed. A goal is to contribute to US industrial competitiveness in the burgeoning microstructures and micromechanical systems market.

Acknowledgments:
This work was carried out by Jet Propulsion Laboratory, California Institute of Technology, under a contract with NASA.